NAIC-ID(RS)T-0555-95

NATIONAL AIR INTELLIGENCE CENTER

EARTH AND THE UNIVERSE.
(Selected Articles)

Approved for public release:
distribution unlimited

19960221 110

DTIC QUALITY INSPECTED 1

NAIC- ID(RS)T-0555-95

PARTIALLY EDITED MACHINE TRANSLATION

NAIC-ID(RS)T-0555-95 22 January 1996

MICROFICHE NR: 96C000026

EARTH AND THE UNIVERSE (Selected Articles)

English pages: 43

Source: "Zemlya i Vselennaya", Nr. 5, 1967; pp. 60-74

Country of origin: USSR
This document is a machine translation processed by:
Input: David Servis, Inc.
F33657-87-D-0096
Post-Edit: SrA Tanja M. Wright
Merge: Connie C. Rust
Quality Control: Nancy L. Burns
Requester: NAIC/TASC/John Gass
Approved for public release: distribution unlimited.

THIS TRANSLATION IS A RENDITION OF THE ORIGINAL FOREIGN TEXT WITHOUT ANY ANALYTICAL OR EDITORIAL COMMENT STATEMENTS OR THEORIES ADVOCATED OR IMPLIED ARE THOSE OF THE SOURCE AND DO NOT NECESSARILY REFLECT THE POSITION OR OPINION OF THE NATIONAL AIR INTELLIGENCE CENTER.	PREPARED BY: TRANSLATION SERVICES NATIONAL AIR INTELLIGENCE CENTER WPAFB, OHIO

TABLE OF CONTENTS

U. S. BOARD ON GEOGRAPHIC NAMES TRANSLITERATION SYSTEM

Block	Italic	Transliteration	Block	Italic	Transliteration
А а	*А а*	A, a	Р р	*Р р*	R, r
Б б	*Б б*	B, b	С с	*С с*	S, s
В в	*В в*	V, v	Т т	*Т т*	T, t
Г г	*Г г*	G, g	У у	*У у*	U, u
Д д	*Д д*	D, d	Ф ф	*Ф ф*	F, f
Е е	*Е е*	Ye, ye; E, e*	Х х	*Х х*	Kh, kh
Ж ж	*Ж ж*	Zh, zh	Ц ц	*Ц ц*	Ts, ts
З з	*З з*	Z, z	Ч ч	*Ч ч*	Ch, ch
И и	*И и*	I, i	Ш ш	*Ш ш*	Sh, sh
Й й	*Й й*	Y, y	Щ щ	*Щ щ*	Shch, shch
К к	*К к*	K, k	Ъ ъ	*Ъ ъ*	"
Л л	*Л л*	L, l	Ы ы	*Ы ы*	Y, y
М м	*М м*	M, m	Ь ь	*Ь ь*	'
Н н	*Н н*	N, n	Э э	*Э э*	E, e
О о	*О о*	O, o	Ю ю	*Ю ю*	Yu, yu
П п	*П п*	P, p	Я я	*Я я*	Ya, ya

*ye initially, after vowels, and after ъ, ь; e elsewhere.
When written as ё in Russian, transliterate as yё or ё.

RUSSIAN AND ENGLISH TRIGONOMETRIC FUNCTIONS

Russian	English	Russian	English	Russian	English
sin	sin	sh	sinh	arc sh	$\sinh^{-1}$
cos	cos	ch	cosh	arc ch	$\cosh^{-1}$
tg	tan	th	tanh	arc th	$\tanh^{-1}$
ctg	cot	cth	coth	arc cth	$\coth^{-1}$
sec	sec	sch	sech	arc sch	sech^{-1}
cosec	csc	csch	csch	arc csch	csch^{-1}

Russian	English
rot	curl
lg	log

GRAPHICS DISCLAIMER

All figures, graphics, tables, equations, etc. merged into this translation were extracted from the best quality copy available.

EARTH AND THE UNIVERSE.

Page 60.

MAIN GEOPHYSICAL OBSERVATORY AND DEVELOPMENT OF DOMESTIC METEOROLOGY.

M. I. Budyko, the corresponding member of the AS USSR, Lenin prize winner.

Noted in the anniversary year by high government reward - the Order of the Red Banner of Labor Main Geophysical Observatory of the name of A. A. Voyeykov - one of the oldest scientific institutions of our country. To the glorious path, by Main Geophysical Observatory, dedicated the article of the director of M. I. Budyko's observatory.

V. N. Karazin (1773-1842).

In the XVIII century it was already established that for understanding of the laws governing the atmospheric processes it is necessary to create the system of the constantly working

meteorological stations, which are located in different regions and conducting observations of the temperature, the air pressure, the wind and other meteorological elements within the identical programs.

However the organization of this observation system proved to be very difficult and it was tightened for many years.

In the beginning of the XIX century the well-known public worker, founder of Kharkov university V. N. Karazin gave the proposal to create in Russia the central institution, which would lead observations at the meteorological stations. In the opinion of Karazina, the organization of this institution together with the system of the meteorological stations subordinated to it would make it possible to develop the methods of weather forecast for the prolonged period.

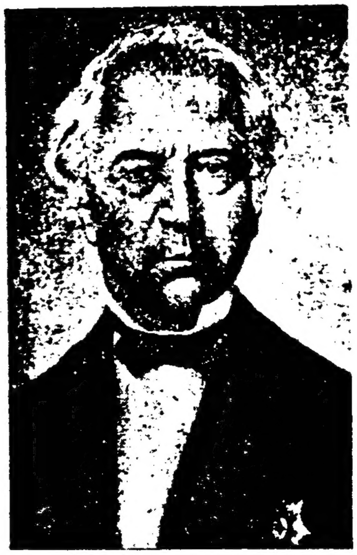
The proposal of Karazina did not enjoy success, since it expressed it, being located in the reference, when the short period of its effect in the government circles was finished. One should, however, note that the appearance of Karazina considerably led to the foundation of central meteorological institutions in any other countries.

Beginning from the 30's of past century the academy A. Ya. Kupfer for the duration of the number of years also proved the need for creation in Russia of central meteorological institution. The

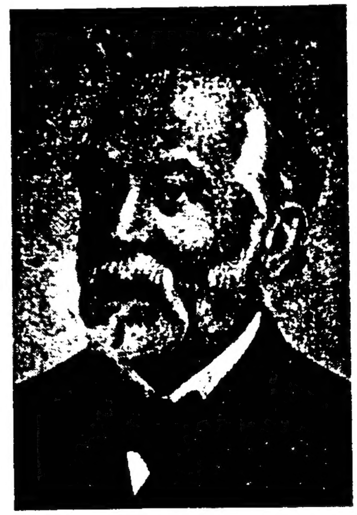
bureaucratic orders of that time tightened the resolution of a question about the organization of institution, and only in 1849 in Petersburg was based main physical observatory - second on the time of foundation important scientific institute of our country (after Pulkovo astronomical observatory).

Page 61.

A. Ya. Kupfer



G. I. Vild'



Academician A. Ya. Kupfer (1799-1865).

Academician G. I. Vild' (1833-1902).

To the main physical observatory were entrusted the problems of the "knowledge of Russian empire in physical sense", moreover special importance was given to the organization of meteorological and magnetic investigations.

In the first years of existence the observatory included only several colleagues, who were being occupied by the organization of operation of meteorological stations, publication of the materials of observations, development of instruments for the meteorological and magnetic observations, and also the works in the region of metrology.

The development of observatory accelerated itself after

designation by director in 1868 of academician G. I.Vild'. Toward the end of the XIX century the observatory became the center of the vast system of meteorological observations, which included hundreds of meteorological stations, several regional observatories and first-class for that time geophysical observatory in Pavlovske, where the wide program of meteorological and magnetic observations was accomplished. Considerable attention in the works of observatory was paid to the development of meteorological instruments and organization of their checking. Beginning from the 70's, in the observatory the weather service, which released short-term forecasts, operated.

The high level of works in the region of meteorology, achieved by observatory in those years, obtained wide international acknowledgement. This was reflected in the selection of G. I. Vild' by the President of the World Meteorological Organization and his designation in the post of the chairman of international board for conducting of the first polar year.

Scientific studies in the observatory was considerably expanded at the end XIX and beginning of the XX centuries, when the activity of observatory was led by academicians A. I. Rykachev and B. B. Golitsyn. The investigations in the region of synoptic and agricultural meteorology, aerology, actinometry, atmospheric electricity were expanded in these years. Especially large works was conducted in the observatory on the study of a climate of our country, in course of which was prepared and published climatological atlas of

Russia, which was the outstanding achievement of the climatography of that time.

A deep effect on the subsequent development of climatological investigations was the work by the most important climatologist A. I. Voyeykov's observatory, who compiled the general layout of the study of a climate of our country and fulfilled the number of valuable works on the applied climatology. In 1916 A. I. Voyeykov passed away, and comprised by them layout of studies was accomplished by Soviet climatologists.

It should be noted that the considerable successes in the development of meteorological investigations, achieved in the pre-revolutionary time, were result, mainly, of initiative and the efforts of individual scientists.

Before the revolution the activity of observatory was limited to a constant deficiency in the means even for fulfilling such primary works as the publication of the materials of meteorological observations and their generalization. Since observatory combined the functions of central scientific institution in the region of meteorology with the functions of the center of operational weather service, then basic part of the colleagues of observatory made a different technical and operational works and could conduct scientific studies only in the off-duty time.

Page 62.

A.I. Voyeykov

V.N. Obolensky

Corresponding member of the Academy of Sciences A. I. Voyeykov (1842-1916).

Professor V. N. Obolensky (1877-1942).

Characterizing the position of the matters, which were established in the observatory before the revolution, its director, academician A. N. Krylov in 1916 wrote: "Observatory, managing the gold placers, was forced to be limited to "prospecting picking" in them, since it does not have the means for their correct development".

After the great October Revolution only the conditions, favorable for the wide development of meteorological investigations in the Main Geophysical Observatory were utilized.

In 1921 at the conference of the Council of Peoples' Commissars

under V. I. Lenin's chairmanship was examined a question about the organization of Soviet weather service. In the decree of 21 June, 1921, to the observatory the management of all meteorological works in our country was entrusted.

Making the resolution of government, the colleagues of observatory conducted great work on the restoration of the system of meteorological observations, which suffered during the years of the first world and civil wars. The weather service was simultaneously reorganized with this: all departmental organizations were either transmitted to observatory or they were eliminated.

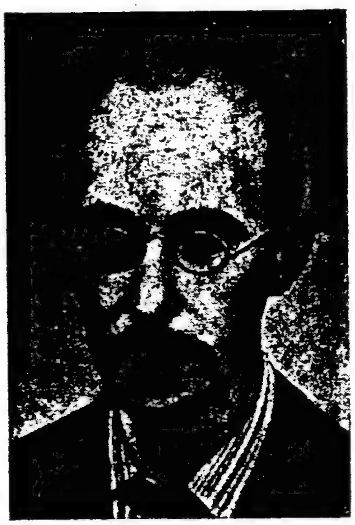
In 1924 was affirmed the first in the years of the Soviet regime the position about the observatory, in which were set its structure, problems in the region of scientific research, administrative and operational work. From this time the observatory was called name "Main Geophysical Observatory".

In 1929 the resolution of government organized the hydrometeorological committee of the USSR, which became the administrative center of hydrometeorological service. Subsequently in Moscow central weather bureau, was converted then into the central institute of predictions. As a result of this the observatory was freed from the administrative functions and from the responsibilities of the center of the weather service, which considerably expanded the possibilities of the development of scientific studies.

In the 20th and 30's the scientific activity of the colleagues of observatory noticeably exceeded the volume of scientific studies, which were being made before the revolution. In these years in the observatory worked the number of the important scientists, from whom S. I. Savinov, V. N. Obolensky, B. P. Weinberg, A. A. Friedman and P. A. Molchanov in their time occupied the post of the director of observatory. Together with the named scientists, in the observatory worked the outstanding specialists into the region of theoretical meteorology - N. Ye. Kochin, P. YA. Polubarinova-Kochina and A. A. Dorodnitsyn (subsequently academicians); Ye. N. Blinov and I. A. Kibel' (subsequently the corresponding members of the AS USSR); in the region of physics of atmosphere - N. N. Kalitina, of P. N. Tverskoy; climatology - A. A. Kaminskiy, e. s Rubenstein; specialists in the region of synoptical meteorology - B. P. Mul'tanovskiy, E. S. Lir and many others.

Page 63.

A.A. Friedman



P.A. Molchanov

Professor A. A. Friedman (1888-1925).

Professor P. A. Molchanov (1893-1941).

During the years of the Great Patriotic War observatory carried heavy damage: experimental base in Pavlovske, long years been by the center of meteorological observations in our country, was completely destroyed. Many colleagues of observatory perished at the front and in besieged Leningrad.

In the beginning of 1942 Main Geophysical Observatory was united with the Leningrad institute of experimental meteorology, which was organized in the thirties for developing the methods of active effects on the atmospheric processes. The fundamental collective of the united institution was evacuated into Sverdlovsk, where under the management of V. Ya. Nikandrov, appointed as the director of

observatory, works for guaranteeing the demands of defense and national economy of wartime were expanded.

The group of colleagues, who remained in Leningrad, composed the Leningrad division of observatory, which by its work helped the defenders of the precipitated city. In the spring of 1944, soon after blockade break-through, observatory was returned to Leningrad, where the staff swept active activity in the restoration and further development of scientific studies of observatory.

In 1946 on the resolution of the government of observatory was transmitted the located in the vicinities of Leningrad settlement of Sel'tsy for the construction in it of new experimental base of the instead of destroyed observatory in Pavlovske.

The taking place in 1949 century of Main Geophysical Observatory was noted as the large holiday of entire Soviet science. Session of academic council confined to this date showed that scientific studies leading in the observatory widely encompass all fundamental directions of physics of atmosphere and climatology. A. I. Voyeykov's name was appropriated to observatory, and Sel'tsy settlement was renamed into Voyeykov settlement.

The scientific activity of observatory in the postwar years continued many directions of the investigations, conducted before the war, and included the development of a whole series of the new

problems of meteorological science. During setting of these problems and their study the colleagues of observatory in many instances led to the achievements of the corresponding directions of foreign investigations.

Let us give now the short characteristic of the fundamental results of the scientific works, carried out in the Main Geophysical Observatory in the last 50 years.

The Soviet school of dynamic meteorology was created in the Main Geophysical Observatory by A. A. Friedman, who in 1920 organized the collective of scientists, who began investigations in this region.

In the work of A. A. Friedman, N. Ye. Kochin and other colleagues of observatory were established the great possibilities of studying the diverse problems of physics of the atmosphere on the basis of the application of methods of theoretical hydromechanics.

Page 64.

Developing these investigations, was by I. A. Kibel' in the work "application to the meteorology of the equations of the mechanics of the baroclinic fluid", published in 1940, developed the numerical method of weather forecast, is based on the solution of the equations of thermohydrodynamics. This work, noted by state prize, and was the beginning of the wide cycle of the investigations, which occupied large place in the Soviet and foreign dynamic meteorology.

In the 40's in the Main Geophysical Observatory of E. N. blinov the beginning of investigation according to the theory of average distributions and anomalies of temperature, pressure and wind in the atmosphere. These investigations, continued then in the central institute of predictions, led to the creation of the first numerical method of long-range weather forecast.

In the postwar years of work on the dynamic meteorology they conducted in the observatory by the large collective of scientists, which led M. I. Yudin; in them were developed the numerical methods of weather forecasts, questions of the theory of atmospheric turbulence and atmosphere circulation.

Large place in the works of Main Geophysical Observatory occupied investigations in the region of climatology.

As early as the 20-30th years A. A. Kaminskiy, Ye. S. Rubenstein and other colleagues prepared the number of monographs according to the climate of our country. Subsequently the local institutions of hydrometeorological service under the management of observatory carried out immense work on the preparation for two publications of the "climatic manual of the USSR", which was the generalization of many-year observational data of meteorological network. Utilizing materials of manual, the colleagues of observatory composed first Soviet "climatological atlas of the USSR", which on the

completeness of its program considerably exceeded the atlases of the foreign countries.

Together with the works on the climatology of the USSR, in the observatory considerable attention was paid to the investigations in the region of applied climatology.

Works of G. T. Selyaninov, S. A. Sapozhnikovoy, I. A. Gol'tsberg in the region of agroclimatology had a great effect on the development of this field of science and had vital importance for the adoption of Soviet subtropics and for guaranteeing different demands of agriculture.

In recent years were considerably expanded those leading in the observatory of investigation on the construction climatology, work on the bioclimatology of man and under the climatic conditions of the industrial pollution of atmosphere was initiated.

Beginning from the 30's specialists in the region of theoretical meteorology considerable attention was given to resolving the problem of the physical explanation of the genesis of climates of terrestial globe.

Large contribution to the development of the theory of climate extra-whether of the investigation of N. Ye. Kochin, continued by the works of E. N. Blinovoy, M. Ye. Shvets and L. R. Rakipovoy. The

work on the study of the heat balance of the Earth and moisture exchange in the atmosphere adjoins to the investigations according to the theory of climate, which were widely swept in the observatory recently. The methods of determining the components of the heat balance of the earth's surface and atmosphere, whose application made it possible to construct the world maps of the distribution of the principal terms of heat balance, were developed. These maps were published in the form of two atlases. Obtained in these materials research subsequently widely were utilized in the Soviet and foreign works on the applied climatology, the theory of climate, hydrology and physical geography.

Laws governing the moisture exchange in the atmosphere were studied in the work of O. A. Drozdov and other colleagues of observatory. In the course of these investigations was developed the quantitative theory of moisture exchange, whose conclusions had vital importance for explaining the effect of land-reclamation actions according to the precipitation. Considerable attention in the climatological investigations was paid to the problem of climate variations from the natural reasons and as a result of artificial effects. In the works on the meteorological effectiveness of land-reclamation actions the effect on the meteorological mode of field-protecting forest cultivation, irrigation, drying of swamps, creation of artificial reservoirs, etc is explained. The possibility in principle of a considerable change in the climatic conditions on the large spaces on the basis of technology and power engineering of

the not very distant future was established in recent years.

Page 65.

Essential place in the activity of Main Geophysical Observatory occupied the works, connected with the development of meteorological network.

The colleagues of observatory dealt with the development of new instruments for the meteorological observations and with the improvement of those of already existing. In the postwar years in the observatory under M. S. Sternzat's management the work on the creation of automatic meteorological station, which opened prospects for the basic reconstruction of the system of meteorological observations, was carried out. High value for the improvement of observations of the clouds and the rainfall had use of the radar technology, on basis of which was developed the construction of the station, which leads observations of the cloudiness and the precipitation.

Investigations in the region of actinometry were initiated in the observatory even in the pre-revolutionary time. In the 20-30th years S. I. Savinov, N. N. Kalitina, Yu. D. Yanishevsky and other colleagues of observatory developed the number of the actinometric instruments, with which the network of actinometric stations was equipped. Based on materials of observations at these stations and as a result of the development of physical investigations was begun the

study of the radiation climate of our country. Actinometric network was developed especially rapidly in the postwar years, moreover by the space of the made observations this network now considerably exceeds those existing abroad.

In systematic sense with the investigations of radiation processes were connected the observations of atmospheric ozone, which were begun in the observatory in the period of preparation and conducting of the International Geophysical Year. The first network of ozonometric stations was created at this time.

The colleagues of Main Geophysical Observatory made a considerable contribution to the development of aerological investigations. These investigations were initiated in the observatory even before the revolution in M. A. Rykachev and by M. N. Pomortsev, and then they were continued and is widely developed by V. V. Kuznetsov and by P. A. Molchanov. In 1929 P. A. Molchanov created the construction of the radiosonde, whose first uplift took place on 30 January, 1930, in Pavlovske. The invention of radiosonde had a deep effect on the development of national and world aerology.

The investigations in physics of clouds and rainfall, initiated in the prewar years by V. N. Obolensky and V. V. Bazilevichem, were further developed in the works of V. Ya. Nikandrov, N. S. Shishkin, Ye. S. Seleznevoy. In the course of these investigations the new methods of the prediction of atmospheric precipitations were

developed and the methods of active effect on the clouds and the fog were substantiated.

Beginning from the 40's, large place in the investigations of Main Geophysical Observatory occupied works in the region of physics of surface boundary layer. In them the mode of turbulent exchange in surface boundary layer was studied, the theory of transformation of an air mass was developed, physical laws governing the microclimate were investigated and the number of the problems of applied meteorology was solved.

From other directions of the works in the region of physics of the atmosphere, represented in the Main Geophysical Observatory, it is necessary to mention investigations in the region of the atmospheric electricity, which for the first time obtained wide development in the work of V. N. Obolensky, who organized the systematic experimental studies of atmospheric electricity.

In estimating the state of the scientific activity of Main Geophysical Observatory, it should be noted that the level of pre-revolutionary works at present is considerably exceeded and observatory occupies one of the leading places in the contemporary geophysical science.

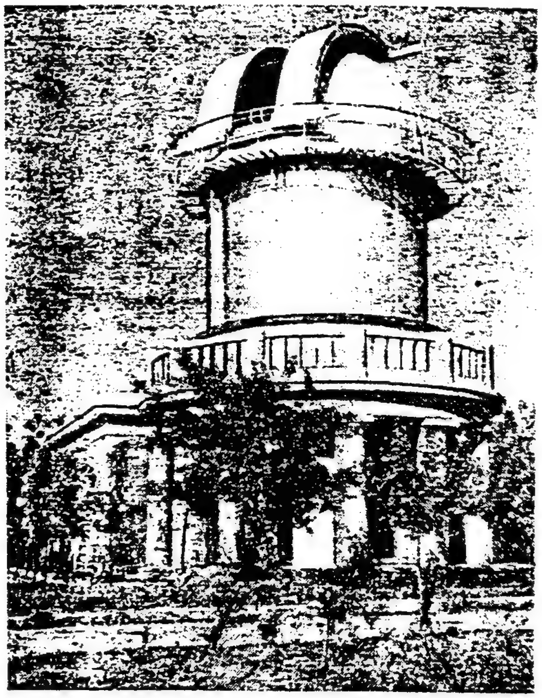
The considerable contribution, introduced by the colleagues of observatory in the development of Soviet meteorology, during January 1967 was noted by the rewarding of Main Geophysical Observatory by the Order of the Red Banner of Labor.

Page 66.

OPTICAL SOLAR RESEARCH IN THE USSR.

A. B. Severnyy, the corresponding member of the AS USSR, the director of the Crimean astrophysical observatory of the AS USSR.

In the first decades of the Soviet regime, as in the pre-revolutionary years, solar research did not exceed the scope of personal interests and tendencies of one astronomer or another. Subsequently of work in this most important field of astrophysics even more acquired the collective nature. But they became properly effective only in the postwar years.



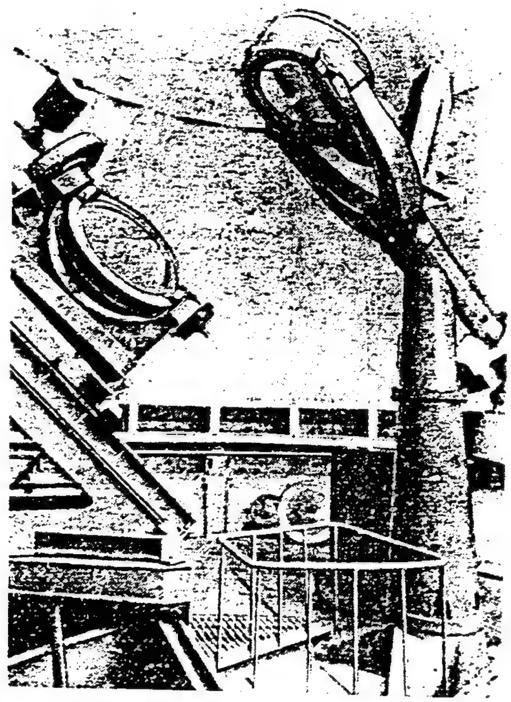


Fig. 1. Tower solar telescope of Crimean astrophysical observatory of AS USSR. To the left - the tower of telescope, to the right - coelostat installation.

Page 67.

The decisive importance is the great achievements in the technology of solar experiments. After the Great Patriotic War were put into operation the large solar telescopes: the horizontal telescope of the system of N. G. Ponomarev in Pulkovo and the tower solar telescope (Fig. 1) in the new astrophysical observatory in the mountainous Crimea (settlement "scientific"), which made it possible to accomplish analyses of the spectrum of the sun upon the dispersion and under the resolving power, highest at the contemporary level. Exceptionally

important role in these investigations played the development of procedure and the manufacture of high-quality diffraction gratings (F. M. Gerasim) and of narrow-band interference-polarizational filters (A. B. Gil'varg and A. B. Severnyy, 1948; S. B. Joffe, 1950). Latter are utilized for the observations, in particular for cinematography of the sun in the rays of hydrogen line $H\alpha$. Successfully are used magnetographs in the photoelectric measurements of magnetic fields in the sun.

The very essential achievement of the postwar development period of solar research was the creation of the wide network of the stations of the service of the sun, which encompasses the range of longitudes from Vladivostok to the western borders of the USSR. This network of the stations, equipped with standard equipment for photographing of the sun and its monochromatic observations in rays $H\alpha$, made possible "patrol", observations of the solar activity almost during are more than half of days. Stations give detailed information about all rapid processes in the sun (flashes, overshoots, blasts), with which are usually connected many geophysical effects. The information of the service of the sun during the International Geophysical Year proved to be especially valuable.

The significant part of the investigations in the field of physics of the sun is concentrated in the Crimean observatory, where large collective works on the problems of heliophysics. By the important center of solar research continues to remain the Pulkovo

observatory with its southern base - solar station hearth of Kislovodskom. At the station systematically is observed the solar corona out of the eclipses (M. N. and R. S. Gnevyshevy and others). Recently established was the largest in the world extra-eclipsing coronograph (with the opening of 535 mm and a focal length of 8 m). Heliophysical observations are conducted also at the high-mountain solar stations not far from Alma Ata and to Abastumani. Solar power plants are in Moscow, Kiev, Tashkent, Azerbaijan, recently began to work solar telescope in Irkutsk.

One of the characteristic features of physics of the sun in our country in the past 50 years was the many-sided study (in essence by spectroscopic, and subsequently cinematographic methods) of the physical processes, which occur in the active regions of the sun and generate flashes, protuberances, flames, etc. The physical state of solar atmosphere as a whole predominantly was investigated abroad. This characteristic is partly conditional, since, and the significant contribution in both directions was made abroad. The spectroscopic studies of the active regions of the sun and chromosphere (that part of the atmosphere of the sun, where emissive lines appear) were initiated in the Pulkovo observatory already in E. Ya. Perepelkin (1928-1935) and it is successfully continued and developed by O. A. Melnikov and by V. P. Vyazanitsyn (in connection with protuberances, 1935). They for the first time established the presence of the high speeds of the disordered motions - the "turbulent" speeds, without which it is not possible to explain the observed large widths of the

emissive spectral lines of chromosphere and protuberances. V. P. Vyazanitsyn also the first (1947) arrived at the conclusion (confirmed recently by N. A. Yakovkin and others) that the glow of protuberances is determined by the flow going from below the solar radiation.

Another distinctive features of Soviet heliophysics - is more attention to the fine structure of solar atmosphere, than to its average macroscopic characteristics. So, V. A. Krat with the colleagues (1958) on the basis of the study of Fraunhofer (nonluminous) and emissive chromospheric lines in the spectrum of the sun developed representation about the chromosphere as about the totality of hot and cold filaments - protuberances. The analysis of the contours of the spectral lines of different atoms showed that the optimum conditions of the glow of different atoms and ions of different elements were different.

Page 68.

This led to the conclusion about "coexistence" in the chromosphere of hot and cold regions (V. A. Krat, T. V. Krat, V. M. Sobolyev).

The amplification of the glow of green and red lines - the brightest in the spectrum of the solar corona - in the regions, occupied with protuberances, also testifies about the peculiar "symbiosis" of a comparatively cold formation, such as is protuberance, with the hot material of corona. In the sun there is a peculiar thin state structure. Very fact of the coexistence of a

comparatively cold chromosphere and protuberances with the temperature is not more than 10000° in the environment of corona with the temperature, which exceeds 1000000°, one of the remarkable in physics of the sun.

The layer of solar atmosphere, critical for the emission of the continuous spectrum, photosphere) has the granular structure (Fig. 2), which revealed the bright photographs of P. Zh. Janssen and A. P. Ganskiy, made even in the beginning of our century.

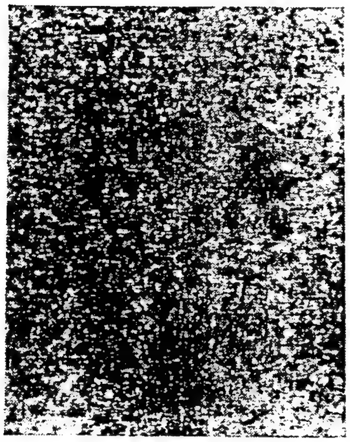


Fig. 2. Solar granulation and small spots (on N. V. Steshenko's photographs, Crimean astrophysical observatory, on 30 June, 1966).

This thin granular structure was studied in the Pulkovo observatory by V. A. Krat with the colleagues (it was determined the time of life of the elements of granulation, speed and the nature of motions; 1954-1956). Lower part of photosphere, strictly speaking, consists of two components - hotter, rise jets and colder, descend. The transverse dimensions of these jets, according to V. A. Krat, is very small (not more than 700 km), and in a number of cases they, possibly, are less than the resolving power of contemporary solar telescopes. The study of the speeds of the motion of gas in the granules and under them showed that the acoustic and gravity waves, which are formed as a result of convection, here play main role. In the upper air of the sun convective motion gradually attenuates, being converted into the turbulent. The alternation of thickening and rarefactions creates sonic noise. The absorption of these noise can be the source of the

stationary heating of chromosphere (E. Ye. Dubov, 1960). Much new in understanding of the solar granulation promises to give the starting of stratoscopes, initiated recently in the Pulkovo observatory.

Especially should be noted the contribution, conducted by S. B. Pikel'ner in the development of the theory of convective motions in the sun. Magnetic field, according to the calculations of S. B. Pikel'ner, more rapidly suppresses turbulence, than convection. Therefore, if magnetic field appears and grows, then, after suppressing turbulence, it facilitates the passage of hot convective jets upwards, creates thus the additional inflow of energy into the photosphere and the increased glow. These considerations help to understand the reasons for the formation of flames and Flocculi.

The detailed spectral studies of active regions in the sun initiated in 1954 in the Crimean observatory made it possible to establish the presence in them of the fine structure of emission.

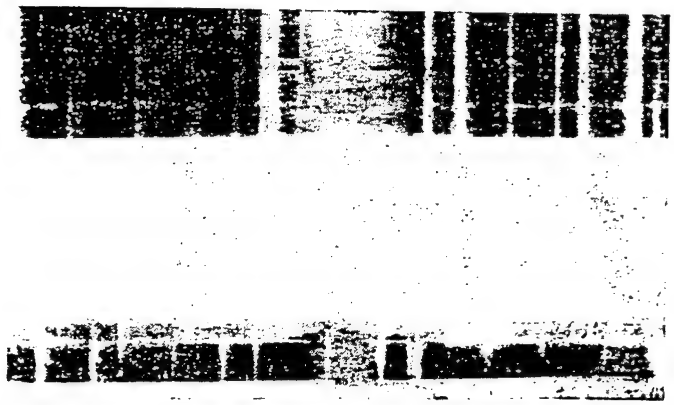


Fig. 3. "whiskers" in line H_α center of disk (above) and at edge itself (below).

Page 69.

As observations under the high resolving power showed, emission in the lines and continuous emission were concentrated in the small, short-lived grains, according to their dimensions of those compared with the resolving power of telescope. Was discovered the frequently appearing, characteristic emission in the lines in the form of the very extended along the spectrum bright wings of lines, named "whiskers" (Fig. 3). Detailed spectrophotometric and cinematographic study showed that in this case we deal concerning the phenomenon, similar to the blast, by the overshoot of jets or by the formation of the moving upwards and downward shock wave fronts. These blasts appear at the different depths and in those places of the atmosphere of the sun, where is noticeably expressed activity (formation of sunspots, their rapid increase, etc.). Fine structure was discovered in the emission of bursts and protuberances (Fig. 4). It turned out

that with good images its elements were similar to the "whiskers" with respect to the mechanism of expansion (A. B. Severnyy, 1954-1959).

The investigations of the emission spectra of solar flares were begun in 1948 in the Crimean observatory (E. R. Mustel', A. B. Severnyy and others). For the first time it was established that the very large widths of emissive lines in the flash spectra are explained by the Stark effect, in other cases the emission is expanded due to the Doppler effect as a result of macroscopic motions of substance. The studies of a change in the magnetic fields during the bursts, and also the positions of bursts relative to magnetic fields led to the conclusion about the important role of the latter in the phenomenon of burst and about the possibility of process, it is analogous with the process of the compression of current cord - pinch effect, that leads to the rapid heating of solar plasma. Crimean of astrophysics obtained the data about the temperature (about 10000°) and the electron density in the bursts, which then were repeatedly confirmed in other works and abroad. The study of the physical state of hydrogen and continuous flash spectrum also lead to the conclusion that the source of energy of the bursts of nonthermal nature, i.e., cannot be obtained due to the redistribution of thermal energy within the atmosphere of the sun. These results were confirmed by the study of the spectrum of the emission of helium in the bursts (N. V. Steshenko and V. L. Khokhlova).

Further, during the detailed study of flash spectrum above the

edge of the solar disk and its changes in the course of time was discovered the clearly expressed stratification (separation into layers) of the physical conditions of bursts on the height in the atmosphere of the sun. A difference in the time-sequential routines of the glow of different elements again confirmed representation about the burst as about the blast, which occurs at a certain height in solar atmosphere and from region of which is propagated the shock wave front, which causes glow in different layers of the atmosphere of the sun (N. N. Stepanyan, E. A. Gurtovenko and others).

The physical state of flocculi (Fig. 5) was examined in the number of the works of E. R. Mustel. It showed that the glow of calcium ions in lines H and K is excited by electron collision, and hydrogen in line $H\alpha$ - by recombination.

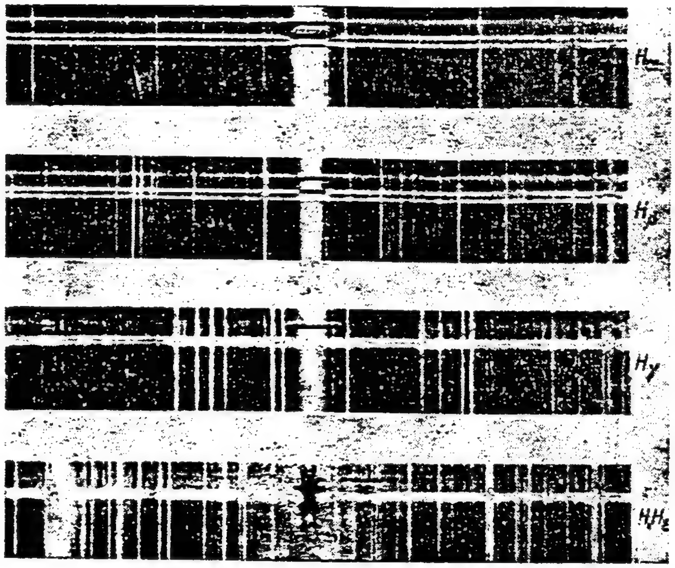


Fig. 4. Fine structure of emissive line reversal in spectrum of solar flare in different lines of hydrogen.

Page 70.

With this can be connected the difference in the form of calcium and hydrogen spectroheliograms, and also different behavior of the infrared lines of calcium ion in the active region and above the spots.

The spectral investigations of transient processes successfully supplemented the cinematographic investigations of the motion of solar plasma in the beams of the line of hydrogen $H\alpha$. Thus, in 1954 in the Crimean astrophysical observatory, where this procedure for the first time in our country was used, they were recorded are rapid motions in the solar flares, which thus far were considered as the always stationary formations (Ye. F. Shaposhnikov and others.).

The connection of different bursts with the nonluminous overshoots and by protuberances was examined Yu. M. Slonim (1957-1961) in the Tashkent observatory. It revealed, in particular, that the appearance of rapid absorption overshoots is characteristic for the impulsive bursts, in which is well expressed explosive phase - rapid lift to the maximum of brightness. In Crimea however, it is established that the bursts are accompanied by quickening of the appearance of nonluminous overshoots and that each such overshoot is connected with the burst; for the burst is characteristic also the lift of the substance of photosphere and the amplification of overshoots from the chromosphere (S. I. Gopasyuk and others).

The motions of solar protuberances reflect the very peculiar behavior of solar plasma. The attempt to explain the fundamental types of such motions, made in Crimea, led to the tentative division of all protuberances into three classes: electromagnetic - with the regular motion of substance along the trajectories, similar to the lines of force of magnetic fields; calm, where the motions are chaotic, and are eruptive, in which is observed the overshoot of the entire mass of protuberance almost radially from the sun (A. B. Severnyy, V. L. Khokhlova).

Fundamental value for understanding of the processes, which occur in the sun, in particular for understanding of the behavior of solar plasma, have the studies of magnetic fields. The systematic

measurements of the magnetic fields of sunspots were initiated by photographic method in 1954 in the Crimean astrophysical observatory on the tower solar telescope (A. B. Severnyy, V. Ye. Stepanov).

Photographic method, however, makes it possible to detect only strong magnetic fields. However, for studying the weak fields on the same telescope in 1956 the photoelectric method of measuring the magnetic fields with the aid of the magnetograph was used. At present magnetographs work also in Moscow, Irkutsk and Pulkovo.

Fig. 5. Flocculi in line $H\alpha$ (photograph it is made on dual spectroheliograph of Crimean astrophysical observatory on 23 August, 1959).

Page 71.

The result of great cooperative work on the measurement of the magnetic fields of sunspots within the period of the International Geophysical Year was the creation of the detailed catalog of magnetic fields and polarities of spots (V. Ye. Stepanov, Ye. F. Shaposhnikov, N. N. Petrov, 1963).

Although a method of the photoelectric recording of weak fields in 1953 for the first time successfully utilized G. Babcock on the observatory of Mount Wilson (USA), American researchers went mainly by means of the qualitative study of the picture of the distribution of longitudinal magnetic field over the solar disk with the low resolving power. This led them to the strong averaging and the desensitization of field and partly to the erroneous conclusions. From the American an increase in the resolution in the solar disk is a fundamental difference in the method, used in the Crimean astrophysical observatory, approximately 50 times. Furthermore, in Crimea was for the first time realized the possibility of photoelectric measurements by the transverse component and the complete vector of field (V. Ye. Stepanov and A. B. Severnyy, 1959; analogous method was developed in 1962 in IZMIRAN - E. I. Mogilevskiy, B. A. Ioshpa and V. N. Obridko).

The application of the high resolving power made it possible to reveal the fine structure of magnetic fields (analogous to the fine structure of emission). So, in contrast the taking root representations, based on the classical work of J. Hale, about the magnetic field of spots as about the field, similar to the field of the top of solenoid, it was explained that there are serious deviations from this picture - the impregnation of cross fields, turbulence of field, concentration of field in the separate bunches and other heterogeneities, which are revealed only during the large resolution and by the photoelectric recording of cross fields (Fig.

6). The discovery of the heterogeneity of fields on the surface of the sun made it necessary to suspect the heterogeneity of field in the depth. The effect of the very strong rotation of the vector of field with the depth in the region of sunspots was discovered. It is interesting that these special features proved to be characteristic for the regions, where different transient processes appear ("whiskers", burst).

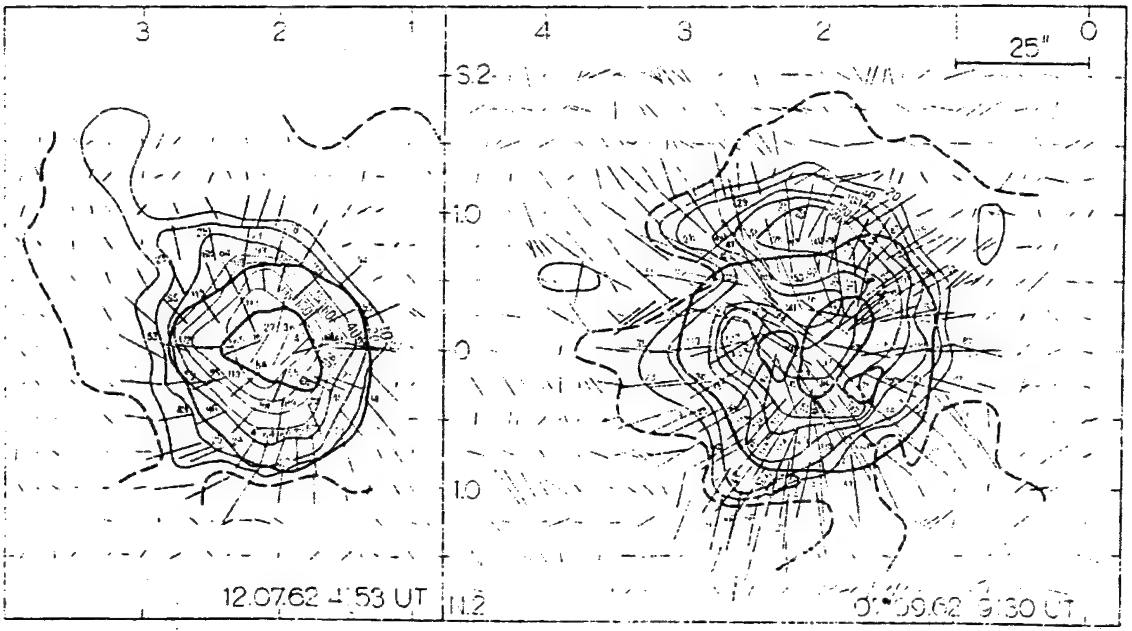


Fig. 6. Fine structure of longitudinal (continuous thin lines - isogausses of longitudinal field) and transverse (arrow) field of single spots.

Page 72.

For such regions characteristically also the appearance of hereabout strong electric currents, which once more speaks tells in favor of the fundamental role of electromagnetic fields in the processes in the sun. These special features of magnetic fields are unstable. The measurements, carried out in 1957-1964 are later in the Crimean observatory, they showed that, for example, with the strong bursts were connected "spasmodic" changes in the magnetic field: before the flash/burst the fields become complicated, field gradients grow, the "hills" of the relief of longitudinal field and sometimes sunspots

converge; the field is simplified after strong burst, gradients fall, the "hills" of field, and now and then also spots themselves are pushed apart.

Spotting out and their development from the magnetic "hills" with the intensity approximately 100 G, according to G. Ya. Vasil'yevoy (1963), also can be accompanied by strong transient processes, change in the magnetic field of "hill" and by abrupt change in the radial velocity. The concentration of strong (more than 1000 G) fields in the small pores is found recently by N. V. Steshenko.

It turned out that not only spot, but also overall (weak) magnetic field of the sun it displays a thin structure (it consists of small elements) and, although on the average to the field of dipole, in terms of times sharply it similarly differs from dipole and is shown strong magnetic "asymmetry" (preponderance of the magnetic flux of one polarity).

The study of magnetic field in the sun requires the development of the theory of the zeeman effect - splitting of spectral lines in the magnetic field - for the lines of absorption, which appear in the optically dense atmosphere of the sun. For this, in turn, it is necessary to solve the equations of radiation transfer in the case of magnetic field. The solution was found by V. Ye. Stepanov (1958, 1960, 1962) and then by D. N. Rachkovskiy (1962). In particular, the latter obtained some exact solutions of the problem about the

radiation transfer and showed the great value of the effects of magnetic rotations.

In Crimea was obtained the number of the essential data about the connection of magnetic fields with the structure and the characteristic formations of upper air of the sun. For example, V. Ye. Stepanov (1960-1961) confirmed the results of the American authors about the close connection between the calcium flocculi and the magnetic fields. T. T. Tsap (1963) revealed that the magnetic fields near the spots repeat well the vortex cyclic structure of chromosphere, seen in the rays of line $H\alpha$. All this verifies the close connection of structure and upper-air conditions of the sun with unit magnetic flux. In a number of cases of field with the solar plasma are ejected to the considerable heights together with the protuberances (G. Zirin, American scientist, who worked in Crimea, 1961; B. A. Ioshp, 1962). However, a question about the interconnection of fields and motion of plasma in the atmosphere of the sun continues to remain one of the insufficiently studied and difficult questions of physics of the sun.

Much attention in the USSR was given to the observations of the solar eclipses, which offer the thus far only possibility of a precise quantitative study of uppermost layers of solar atmosphere - chromosphere and corona (Fig. 7). The study of the structure of corona and its connection with the active formations in low layers of solar atmosphere was here most important result. In 1954 Ye. Ya.

Bugoslavskaya and S. K. Vsekhsvyatskiy investigated motions and physical characteristics of the parts of corona. In particular, they revealed that the bright jets, which appear sometimes in the chromosphere, underlie of coronal rays and have slope identical to them, which, possibly, is connected with the action of weak local magnetic field. The periodicity of the monochromatic glow of corona with the 11-year-old cycle was discovered, and is in particular opened the two-peak maximum of the glow of corona (M. N. Gnevyshev).

Among the theoretical works, dedicated to questions of physics of corona and chromosphere, first of all must be mentioned the calculation of the ultraviolet radiation of corona and chromosphere, conducted by I. S. Shklovskiy in 1949. I. S. Shklovskiy for the first time noted the important role of the X-radiation of these upper layers of solar atmosphere in the formation of the D-layer of the ionosphere of the Earth. Detailed theoretical studies of the chemical composition and ionization of chromosphere and corona on the basis of the observations of total energy, emitted by corona in the separate emissive lines, is carried out by it.

Page 73.

Most recently in connection with the appearing possibility of measuring the X-ray and ultraviolet radiation of the sun with the aid of the artificial Earth satellites and rockets were carried out valuable experimental and theoretical studies. Thus, by A. I. Yefremov and others (1961) discovered the amplification of X-radiation

during the solar flares, and by S. L. Mandelstam and others measured the radiation in the ultraviolet line of hydrogen L_α, are obtained the photographs of the sun in the X-rays (1961-1964) and X-ray burst in the undisturbed region of the sun is recently discovered.

However the exoatmospheric analyses of the ultraviolet and X-radiation of the sun did not thus far yet obtain a sufficient development that it is connected partly with the difficulties of the accomplishment of similar experiments. In spite of this, should be noted some important works on the interpretation of the ultraviolet spectrum of corona and chromosphere, carried out by G. M. Nikol'skiy and G. S. Ivanovym-Xolodn.

Now let us pause at the problem of the effect of the sun to the earth. Most successfully was developed a question about the solar corpuscular fluxes and their effect on the earth (E. R. Mustel' and his colleagues, 1963; S. K. Vsekhsvyatskiy, 1963). The question about the localization in the sun of the source of solar particles, in particular those, which cause 27-day magnetic perturbation on the Earth, is most difficult. E. R. Mustel' (1942-1958 yr.) made the conclusion that the centers of activity (flocculus), which generate corpuscles with speeds of from 150 km/s to 500 km/s, are critical for magnetic perturbation. Analyzing special feature of the centers of activity and different types of geomagnetic disturbances, E. R. Mustel' showed that in the sun there are two types of coronal flows. In the "calm" regions of the sun, where there are no flames, there is

a common outflow of gas condensations, which leave the sun with a velocity of 300-400 km/s and which carry with itself the "frozen-in" in them magnetic fields. Above the active regions (flames) the corona is the accumulation of the radially directed tubes of the lines of force (R-rays), which stretch far into the interplanetary space.

Representation about the coronal beams as about the radially directed particle fluxes was developed also by S. K. Vsekhsvyatskiy and his colleagues. They connected the position of these flows with the chromospheric jets, and in particular with the filaments and the protuberances. From this point of view the flows, which comes from the corona, can take away magnetic field with themselves. The number of considerations, and also measurements at the interplanetary space stations attest to the fact that this field is force-free, i.e., in it the behavior of plasma is determined by the wholly magnetic strength (E. I. Mogilevskiy, 1965).

In the short survey it is difficult to list all fundamental achievements in the region of optical solar research in the past 50 years. We isolated only some, that illustrate the level of these investigations, checked to some degree in the course of the subsequent works and characterizing face of Soviet heliophysics.

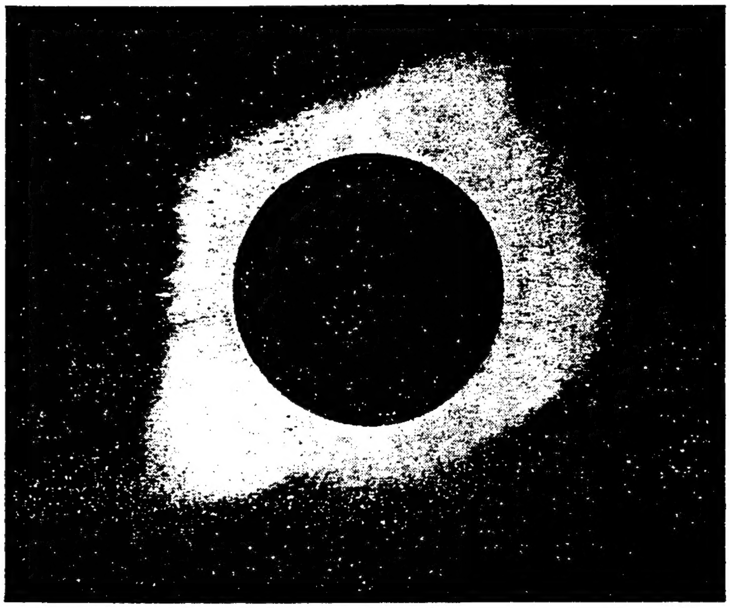


Fig. 7. Photograph of solar corona during eclipse on 25 February, 1952, (on photographs of Tashkent astronomical observatory).

Page 74.

Together with them were carried out also separate basic research on the energy distribution in the spectrum of the sun (G. F. Sitnik), physical state of protuberances and chromosphere (G. S. Ivanov-Xolodnyl, E. V. Kononovich, E. Ye. Dubov and others), laws governing the solar activity (B. M. Rubashev, M. N. Gnevyshev, M. S. Eygenson and others). Although the Soviet heliophysics has, as we saw, sizable achievements, the final solution of the majority of problems lies down on the arms of future generations. Phenomena on the nearest star to us, named the sun, store in themselves much mysterious and incomprehensible to us, until now.

DISTRIBUTION LIST

DISTRIBUTION DIRECT TO RECIPIENT

ORGANIZATION	MICROFICHE
B085 DIA/RTS-2FI	1
C509 BALLOC509 BALLISTIC RES LAB	1
C510 R&T LABS/AVEADCOM	1
C513 ARRADCOM	1
C535 AVRADCOM/TSARCOM	1
C539 TRASANA	1
Q592 FSTC	4
Q619 MSIC REDSTONE	1
Q008 NTIC	1
Q043 AFMIC-IS	1
E404 AEDC/DOF	1
E410 AFDTC/IN	1
E429 SD/IND	1
P005 DOE/ISA/DDI	1
1051 AFIT/LDE	1
P090 NSA/CDB	1

Microfiche Nbr: FTD96C000026
NAIC-ID(RS)T-0555-95